TECHNOLOGY DRIVEN. WARFIGHTER FOCUSED.

Robotics CTA

27 August 2008

Agenda

- **Presentation on technical aspects of PA**
  Jon Bornstein
- **Q&A**
- **Presentation on collaboration, Articles of Collaboration, etc.**
  Patty Fox
- **“One-on-one” meetings**
  Jon Bornstein
  MaryAnne Fields
  Sue Hill

How will unmanned systems impact the Future Force ?

- What missions will they conduct ? What level of capability?
- What degree of autonomy will they possess?
- How will they work with soldiers ? Or function in general society?
- How will they be used in Urban operations? In complex terrain?
- How will they navigate in GPS denied environments ?

Nearly Autonomous Unmanned Systems

Like another soldier in the squad: understanding commander's intent; highly capable; requiring reduced communication and minimal soldier interaction; flexible, robust, and reliable; able to adapt fully to new & different tactical and environmental conditions; effectively operating in mixed environments; able to "learn from experience;" maneuvering unfettered in complex terrain; able to "live" in an world designed for humans, to grasp small objects, to open doors, or to carry the wounded.

UNCLASSIFIED

ARL Research Objectives

Supporting the Soldier

Combining Internal Research with External Collaborations

The New Robotics Collaborative Technology Alliance (CTA)

Program Objectives:

- Conduct core research necessary for the development of future nearly autonomous unmanned systems
  - Basic Research to explore new concepts and ideas
  - Applied Research focused beyond FCS threshold requirements including other future Army unmanned systems programs
- Advance four key component technologies
  - Perception
  - Intelligence
  - Human-robot interaction
  - Dexterous manipulation & unique mobility
- Conduct technology integration & assessment
  - Maintain & continually update testbeds & other specialized equipment
- Transition technology to Advanced Development & acquisition programs
- Enhance collaboration with ARL Researchers
  - Collaborative research
  - Educational opportunities
  - Technology workshops
  - Common research progress reviews

Taking technology beyond FCS thresholds

Perception

Perceive & understand a dynamic & unknown environment

Related ARL Research Activities:

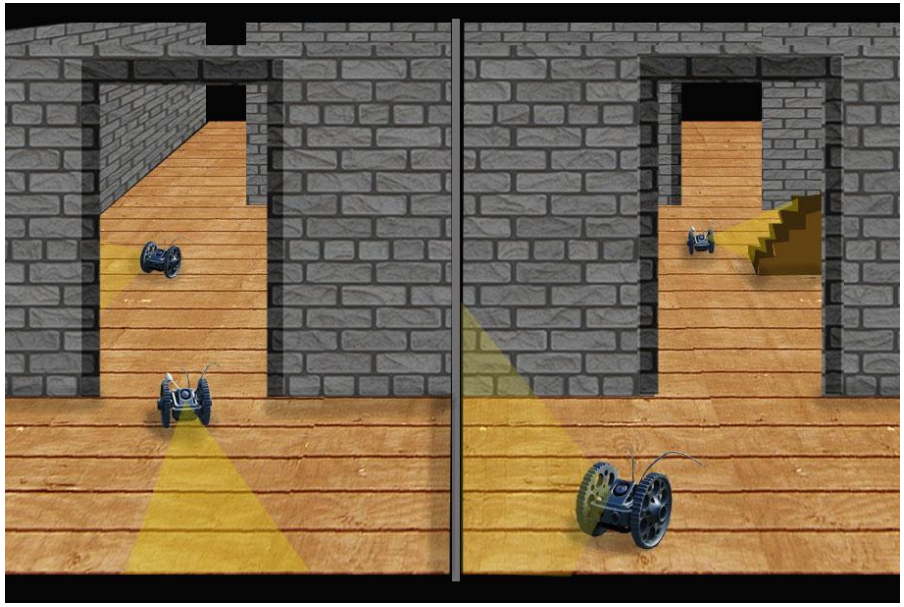
- ***CISD:*** *Integration of perception technology on backpackable robots*
- ***HRED:*** *Cognitive approach to scene understanding*
- ***SEDD:*** *LADAR & RF sensor development; Multi-spectral image understanding Acoustic sensing*
- ***VTD:*** *Sensing for autonomous mobility*

Some potential research topics

- **Sensing**
  - **Greater resolution & range, lower cost**
  - **Increased fields of view**
  - **Scale**
  - **All weather/environments**
- **Terrain/Object Understanding**
  - **Broader vocabulary**
  - **Recognition of cues/saliency of observations**
  - **Robust & adaptive**
  - **Reasoning**
  - **Fusion**
- **Understanding activity**
  - **Human activity/intent recognition**
  - **Saliency of observations/ context & cues**
  - **Learning**
- **World model**
  - **Managed & validated**
  - **Long-term & short-term memory**
  - **Collaborative or distributed**
  - **Common ground (HRI)**
  - **Navigation (Intelligence, mobility & manipulation)**

Intelligence

Plan and execute military tasks & missions



Related ARL Research Activities:

- *CISD: Mapping interior spaces*
- *HRED: Implementation of cognitive learning architecture – adapted for a small, back-packable robot*
- *VTD: Navigation planning with landmark position uncertainty*

Some potential research topics

- **Learn & Adapt**
  - **Deductive reasoning**
  - **Inference**
  - **Generalization/Rules of engagement**
  - **Uncertainty of future conditions**
  - **Probabilistic reasoning**
  - **Spatial & temporal reasoning**
- **Self-awareness/introspection**
  - **Transparency**
  - **Providing non-verbal cues**
  - **Human-robot collaboration**
  - **Fault detection**
- **World model**
  - **Common ground**
  - **Mixed initiative**
- **Scale**
  - **Adapting to resource limitations**
- **Tactically intelligent behavior**
- **Collaboration between homogeneous & heterogeneous systems**

Human-Robot Interaction

Seamless integration of robots into military & civilian activity

Some potential research topics

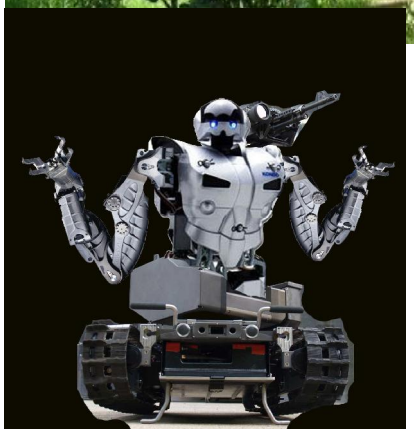
- **Shared situational awareness**
  - **Aware of cultural and behavioral norms.**
  - **Comprehend commanders intent & act upon it**
  - **Understand the intent of surrounding humans for consideration in planning**
  - **Possess common spatial & temporal frames of reference – a "common ground"**
- **Trust & Confidence**
  - **Transparency of action**
  - **Cues to activity**
  - **Tolerance to failure**
- **Intuitive Communication**
  - **Language – unconstrained dialogue**
  - **Non-verbal cues, gestures, context, & behavior**
- **Operating within society**
  - **Adaptable to varying social cues & context**
- **Span of control**

Related ARL Research Activities:

- ***HRED:*** ***Research in soldier-robot teaming, trust in automation, & tolerance to failure***
  Research in multi-modal interfaces
  Research in cognitive workload

Manipulation & Mobility

Manipulation of objects with near-human dexterity & unfettered mobility in 3-D



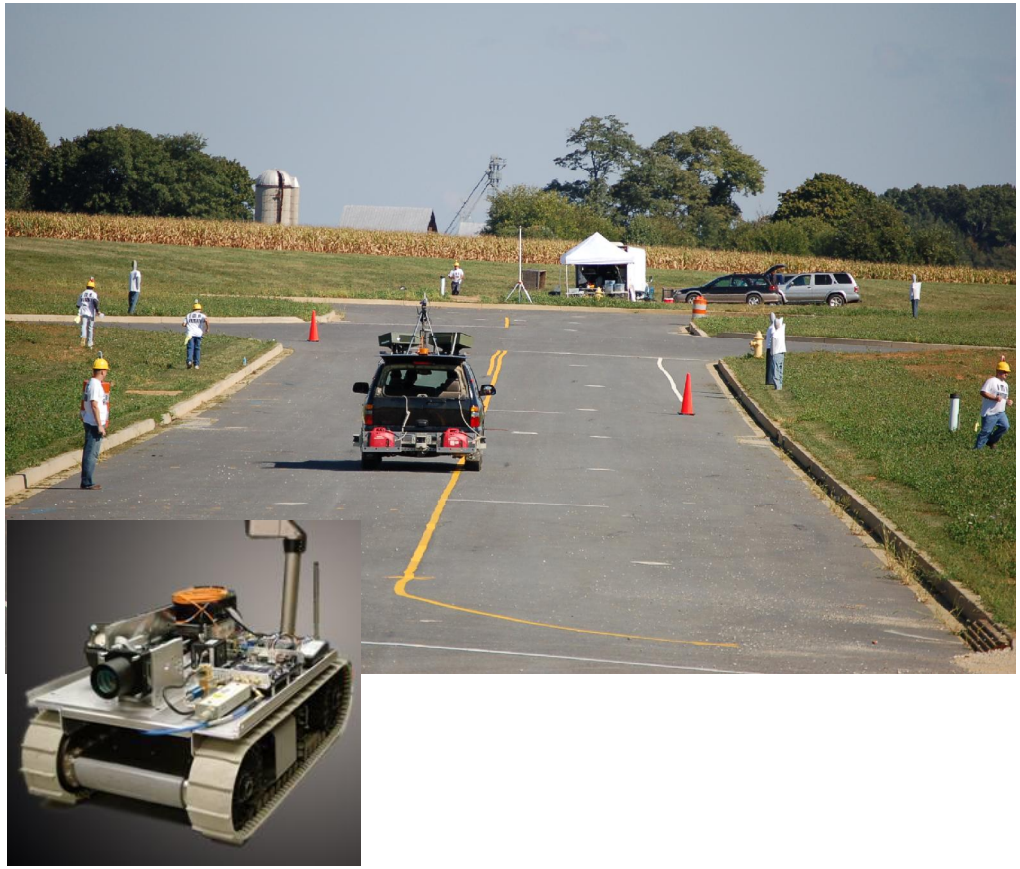
Some potential research topics

- **Human-like manipulation**
  - **Range of motion**
  - **Dexterity**
  - **Strength**
- **Control**
- **Efficiency**
- **Automation/Intelligence**
- **Close coupling of perception, planning, & control**
- **Mobility in complex three-dimensional environments**
  - **Urban**
  - **Jungle/Riverine**
  - **Confined spaces**
- **Animal-like adaptability to changing conditions - reconfigurable**
- **Learning from prior experience**

Related ARL Research Activities:

- ***VTD:*** ***Autonomous manipulation for back-packable robots***
  Mechanics for micro-systems

Integration & Assessment



- **Integration of component technology on to a set relevant testbeds**
  - **Establishment of testbed infrastructure**
  - **Process for establishing technology maturity**
  - **Process for integrating disparate technologies onto laboratory testbeds, e.g., hardware & software ICD's**
- **Conduct technology assessments & demonstrations**
  - **Define process for regular assessment**
  - **Establish structured plan for experimentation**
  - **Establish roles and responsibilities for planning and execution**
  - **Establish necessary infrastructure**
    - **Experimental design**
    - **Data acquisition**
    - **Data analysis tools**
- **Maintenance of testbed fleet & specialized equipment**
  - **Technician staffing**
  - **Spare parts & components**
  - **Continuous equipment upgrades**

Related ARL Research Activities:

- ***Autonomous Systems STI: Technology Integration & assessment for small systems***

  CISD: Experimental Design

  In conjunction with NIST: Infrastructure for technology assessment

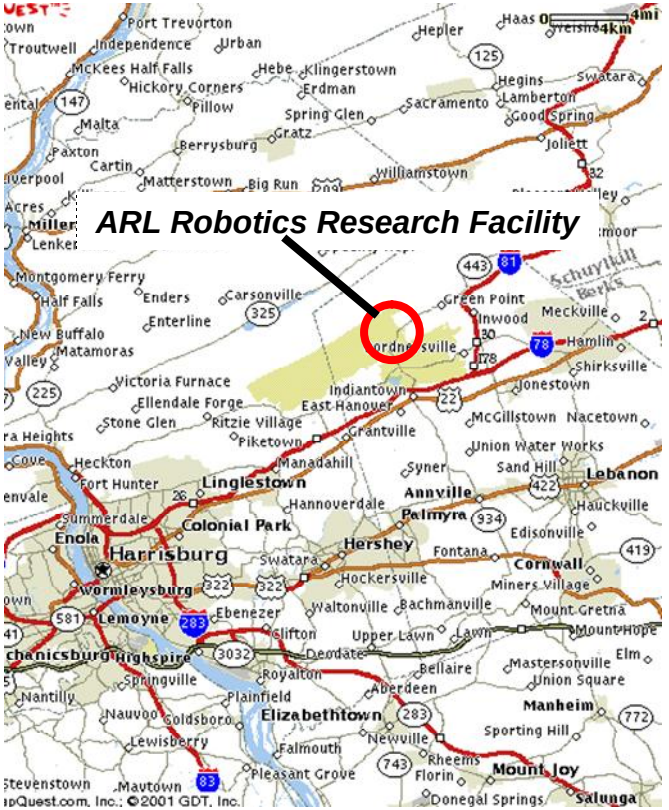
Available Facilities & Equipment

- Integration & Experimentation facilities at
  - Aberdeen Proving Ground, MD
  - Adelphi, MD
  - Ft. Indiantown Gap, PA
- Continuing relationships with
  - Aberdeen Test Center
  - National Institute of Standards & Technology
- Testbed vehicles
  - XUVs
  - TAC-Cs
  - iRobot Packbots
- Modeling & Simulation Environments
  - GEN I SIL
  - RIVET

Open House – 23 October 2008

ARL's Ft. Indiantown Gap Research Facility

An opportunity to visit our facility and meet ARL researchers



Additional information, maps, & registration forms will be posted on the Robotics CTA webpage

Summary

- Collaborative Alliance between ARL & a Consortium of academic & industrial partners
- Focused upon cutting edge research in perception, intelligence, human-robot interaction, manipulation & mobility
  - Basic research aimed at exploring new concepts
  - Applied research focused upon application to military relevant applications
- Research directed to future nearly autonomous unmanned systems
  - Primarily ground vehicles, but with wider applicability
- CTA will emphasize a common research program including joint research, reviews, & workshops
- The Robotics CTA will provide the Army & DoD with the core technology required to field the next generation of highly capable & autonomous unmanned systems




Seeking creative, innovative, and flexible approaches

Further Information

Further questions can be addressed to the Questions & Answers link @ www.arl.army.mil/robotics

For additional information consult:

Army Vision	**www.army.mil**
TRADOC Future Operating Capabilities:	**www.tradoc.army.mil/tpubs/pamndx.htm**
New Robotics CTA Website:	**www.arl.army.mil/robotics**
ARL Website (Links to Robotics & MAST CTAs)	**www.arl.army.mil**